

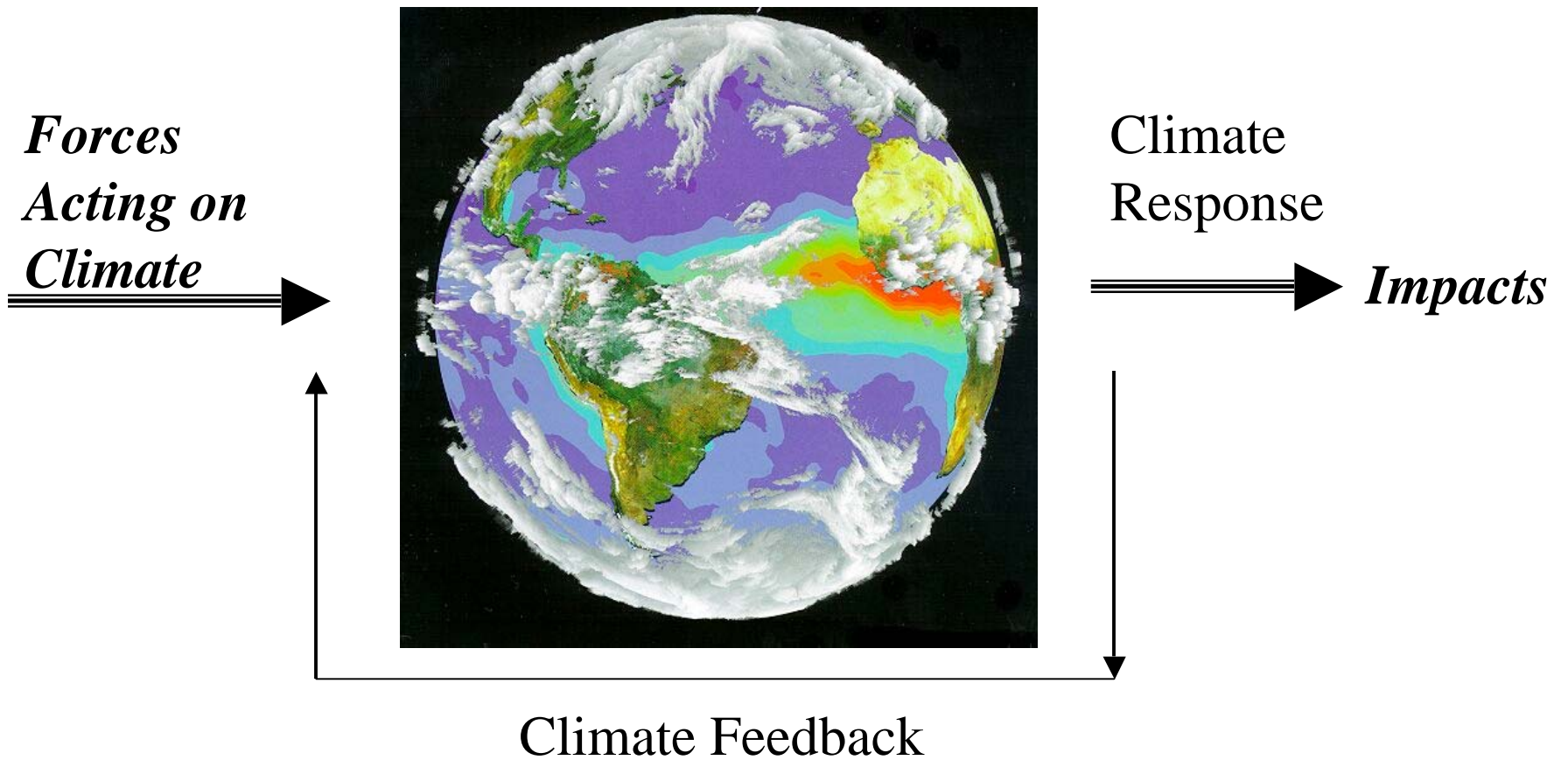
# NASA Global Change Research Objectives

Presentation to the “Living with a Star” Meeting  
Goddard Space Flight Center, 11 May 2000  
Pierre Morel  
NASA Office of Earth Science

# Hierarchy of Science Questions

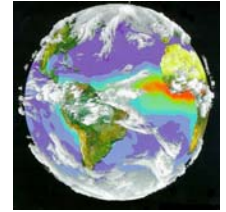
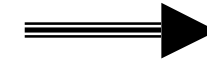
- How is the global Earth system changing?
- What are the primary forcings of the Earth system?
- How does the Earth system respond to natural and human-induced changes?
- What are the consequences of change in the Earth system for human civilization?
- How well can we predict the changes to the Earth system that will take place in the future?

# Earth's Climate System



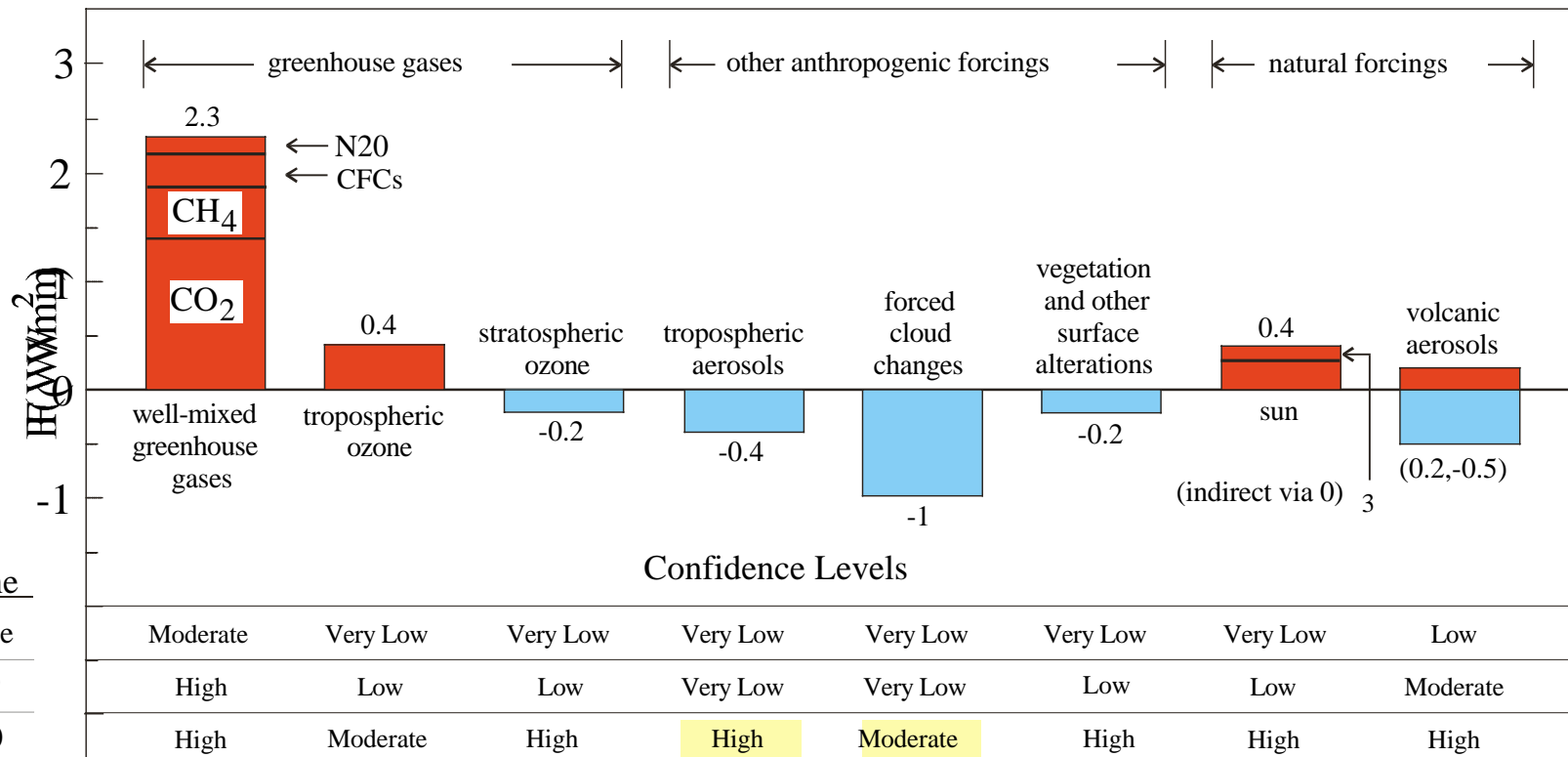
# What we know today

*Climate  
Forcing*



## Forces Acting on Climate

(in Watts per meter<sup>2</sup>)



## Hemispheric Responses to a 0.1 % Change in Solar Irradiance

	N. Hemisphere	S. Hemisphere
$\Delta\text{OLR (seasonal)}$	21 Watt/m <sup>2</sup>	9 Watt/m <sup>2</sup>
$\Delta\text{T (seasonal)}$	11.7 K	5.1 K
$\Delta\text{S}_{\text{Sun}}$	1.4 Watt/m <sup>2</sup>	
$1/4 \Delta\text{S}_{\text{Sun}} (1 - A)$	0.25 Watt/m <sup>2</sup>	
$\Delta\text{T}_{\text{Solar cycle}}$	0.14 K	0.141 K

# Response of the Earth Climate to Forcing

Chaotic nature of climate dynamics implies that the *response* to even a small external disturbance (*forcing*) may be substantial.

True for deterministic prediction (e.g. weather forecasting).  
Can weather ten days ahead be influenced by the flapping of a butterfly's wing (or a minor change in solar fluxes)?

The atmosphere is a powerful “*weather noise*” generator.  
The butterfly is flapping its wings inside a cement mixer.

# Solar Forcing of the Earth Climate

- Direct solar forcing of the Earth radiative balance and climatic equilibrium  
*Reconstruct the record of past changes in solar irradiance*
- Direct solar forcing of the mesosphere/stratosphere  
*Ozone photochemistry*  
*Radiation transfer and temperature structure/stratification*  
*Catalytic effects (e. g. PSC's)? Triggering of “oscillations”*
- Stratosphere-troposphere interactions (dynamical/radiative)  
*By what mechanism can changes in the stratosphere affect tropospheric climate?*
- Others potential “exotic” processes

# Code Y Research Areas of Interest

## 1. Solar Radiation

*Physics of solar activity and radiation output (Code S lead);  
Proxy indicators of past changes (Code S lead).*

## 2. Stratospheric Chemical and Physical Responses

*Major Code Y program*

## 3. Stratosphere-Troposphere Interactions

*Propagation of troposphere-generated waves.  
Radiative impacts of solar-induced changes in composition..*

## 4. Direct Solar Influences on Tropospheric Processes

*Requires specific hypothesis about operative process(es)  
**and** research protocol to validate or invalidate the hypothesis.*



# Code Y non-Global Change Research Interests

1. State of the Ionosphere (Total Electronic Content)  
*Perturbation of magnetic readings of the Earth interior;*  
*Forcing of magneto-telluric currents;*  
*Applications of GPS bistatic electromagnetic sounding.*
2. Geomagnetism  
*Advanced sensors.*  
*Guest instruments on research satellite missions*